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TESTING REPELLENTS AND CONTROL MEASURES FOR THE MOUNTAIN-PINE BEETLE AND STUDYING CERTAIN PHASES OF ITS LIFE HISTORY IN LODGEPOLE PINE

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Respectfully Submitted

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SEARCHING FOR A REPELLENT OR POISON FOR THE MOUNTAIN-PINE BEETLE

Extension of the territory in which the mountain-pine beetle is becoming destructive has made the problem of protecting trees of high aesthetic value an increasingly important one. Such trees are located around summer homes, camp grounds, lake shores, and national parks, and include such tree species as lodgepole, western white, whitebark, limber, and yellow pine.

In 1931 an effort was made to prevent the attack of the historic lodgepole pine at the Battlefield on the Beaverhead National Forest. The boles of these trees were sprayed with creosote to a height of from 15 to 20 feet, but the treatment failed to prevent attack by the beetles. To determine the repellent qualities of a number of materials a comprehensive series of tests were instituted on the Battlefield and Elkhorn areas of the Beaverhead Forest during the 1932 season. At the time the experiments were begun, the following conditions prevailed: At the Battlefield the trees susceptible to attack were few in number, necessitating treating with a highly repellent material in order to prevent attacks from the large supply of beetles within the area. In contrast to this situation the supply of trees at Elkhorn being still in excess of the number which would be attacked in 1932, it was recognized that a milder repellent might delay or prevent attack.

The materials tested on both areas were as follows:

Pyridine
Ortnodichlorobenzene (Ortnene)
Zinc-meta-arsenate
Flu-si dust

Materials tested only at Elkhorn were:

Sodium fluosilicate
Paradichlorobenzene
Termex) Hercules Powder
Impregnation formula) Company products.

In testing these chemicals some trees were treated immediately before attack, others during the time the insects were attacking, and the remainder at various times following attack. The spraying equipment used consisted of a 5-gallon, shoulder type, Hanner hand pump; and for dusting, a Root, shoulder type, hand machine. The method consisted of spraying or dusting the bole of the trees selected as being susceptible to insect attack, to a height of from ten to twelve feet. In addition to the use of undiluted materials, different strength mixtures and emulsions were also tested. The various treatments are discussed under headings corresponding to the name of the chemical used.

Pyridine

At the Battlefield and camp grounds adjoining, 20 lodgepole pines above 5" d.b.h. were sprayed with pyridine to an average height of 11 feet using approximately four gallons of chemical to ten trees. Some of these trees had been previously sprayed in 1932 with orthodichlorobenzene (trade name orthene) or zinc-meta-arsenate, or dusted with flu-si dust, which is a mixture of sodium fluosilicate and an inert dust. A few of these previously treated trees had already been very lightly attacked in 1932. Between the date of treatment, which was July 30, and the first examination on August 10, eight of the pyridine-treated trees were attacked. When the last examination was made on October 22, only one of these trees remained free from attack.

Under conditions such as existed at the Battlefield in 1932, pyridine was unable to repel the attacks of the mountain-pine beetle more than

a few days. At Elkhorn, however, there was adequate host material and the beetles apparently preferred in most cases to seek other food rather than attack the treated trees. No attacks were made on pyridine-sprayed trees for three weeks and no successful attacks until nearly six weeks. It is probable that pyridine loses much of its effectiveness in a few weeks which may account for attacks subsequent to that time. Observations at both the Battlefield and at Elkhorn indicate that attacks are decidedly less numerous on pyridine treated portions of a tree than on the untreated part.

The foregoing discussion indicates that pyridine used in the manner described is ineffective as a repellent for the mountain-pine beetle. The writer believes, however, that a combination of pyridine with a material such as paraffin may retain the more volatile fractions for a longer period of time and make a more effective repellent. Extra spraying at intervals of from 10 to 14 days during the period of heaviest attack and at longer intervals later, may repel the beetles.

Qualities which may preclude the general use of pyridine even if it can be developed into an effective repellent are objectionable odor, staining of the tree, and defoliation of grass and shrubbery. Grass and shrubs which were around the base of the treated trees will be examined in 1933 to determine if permanent injury followed.

Orthodichlorobenzene - Trade Name "Orthene"

This chemical was applied to the lower 10-12 feet of 22 trees at the Battlefield; eleven being treated on July 1 and the remainder on July 30. Two of the trees sprayed on July 30 had also been dusted with Flu-si earlier in July of 1932 and many sprayed with creosote in 1931. By October 22, 1932, practically all these treated trees had been attacked, although some may

have subsequently "pitched-out" the infesting beetles. In a few of the heavily attacked trees, fresh boring dust and enlarged pitch tubes showed the beetles had continued egg gallery construction for a short time after the trees had been sprayed. Then beetle activity had ceased and the short egg galleries, dead parent adults, larvae, and eggs indicated delayed control of the insects.

At Elkhorn Ranger Station 49 more trees were treated with orthene or emulsions of it at various times and under different conditions in an effort to thoroughly test its repellent effect. It seemed to offer a certain amount of protection for a limited time, but insufficient to prevent ultimate attack of the tree. This material did, however, indicate some control of the infesting brood, the extent of which is to be determined in June of 1933 by thorough examination of the trees on both areas. If the examinations show control was secured with orthene further tests will be made of it in 1933.

Zinc-Meta-Arsenate

This chemical was tried on many trees both at the Battlefield and at Elkhorn. At neither place did it give any indications of effectiveness. In fact, at Elkhorn the zinc-meta-arsenate-treated trees were among the first to be attacked and examinations in October and November failed to show results warranting the statement that any control was secured.

In the hopes of making a solution that would adhere for a longer time and thus be more effective, soap was first dissolved in water and then added to the zinc-meta-arsenate. Heat was evolved from this mixture and the soap seemed to be precipitated, necessitating straining of the solution before it could be sprayed on the trees. As a repellent zinc-meta-arsenate seems wholly ineffective and while examinations in the spring of 1933 might show

delayed control of infesting insects, there seems little likelihood of this occurring.

Flu-Si Dust

In July 24, lodgepole pine at the Battlefield were treated with a mixture of "Flu-Si" dust and flour. Difficulty was encountered in securing a good coverage on the bark with the dust. It is felt that the lower and under side of bark scales could not be reached by dusting methods. No repellent effect was noticed from this chemical but there were some indications of partial control of the attacking insects. Many dead beetles were found at the base of dusted trees and dead parent adults were observed in their galleries in excess of the number ordinarily to be found in untreated trees. A greater number of trees were treated at Elkhorn with the same material and variations in the method of applying but no indication of a repellent effect were observed. As at the Battlefield, dead beetles were observed on the bark and ground. Wetting the tree prior to dusting increased the coverage and adherence of the dust only temporarily.

Sodium Fluosilicate

This material was the chemically pure product and the ingredient of "Flu-Si" dust having insecticidal qualities. In treating with this material, trees which were being actively attacked were selected, because the element of tree immunity was thereby eliminated and repellent effect could be measured by the amount of subsequent attack. Examinations made after treatment showed attacks had continued, but many dead beetles were found at the base of the tree and on the bark. It is possible that some control of brood under the bark was secured by this treatment, but that can not be definitely determined until June of 1933.

In an effort to make the chemical adhere to the bark more firmly than by the dusting method, it was mixed with water in which it was held in suspension and then sprayed on the trees. When the spray dried the dust was more thoroughly and evenly distributed and possibly more adherent than was secured by the dusting method.

Termex and Impregnation Formula

Neither of these two chemicals prevented attack of lodgepole pine nor afforded appreciable control of attacking insects.

Paradichlorobenzene Dissolved in Linseed Oil

Trees were sprayed with this mixture during the time they were being attacked and others prior to attack. The mixture was not successful as a repellent, but the trees were so lightly infested it is doubtful if they will be killed. The final effect of this material will be determined in June of 1933.

Summary of Repellent Tests

None of the materials tested in 1932 prevented attack of lodgepole pine by the mountain-pine beetle. A few chemicals indicated a 100 per cent repellent effect for a short period and a reduction in the final number of attacks that would have occurred had the trees not been treated. The last statement is based on the much heavier infestation noted on untreated portions of the trees. While the goal set for these experiments was not attained there is a slight possibility that one or more of the chemicals may be found to have had a delayed effect and controlled the beetles after they had attacked the tree. In that case, provided the damage caused by the insects before they were killed is not too great, the trees may survive the attack. The examinations in June will determine this point.

The repelling of attack for a short period of time by treatment with pyridine indicates the more volatile fractions of the chemical may be most repellent, in which case their retention on the tree would probably afford protection indefinitely. Paraffin or some heavy oil mixed with pyridine may give this result, and experimentation with such a mixture is recommended. Repeated sprayings at short intervals during the period of heaviest attack might also be found effective.

Other recommendations must be withheld until the examinations are completed in June.

SPRAYING A LODGEPOLE PINE WITH PYRIDINE TO PREVENT THE EMERGENCE OF INFESTING MOUNTAIN-PINE BEETLE BROOD

On July 12, 1932, a 15-inch lodgepole pine heavily infested with the mountain-pine beetle was sprayed on the southwest side with pyridine to a height of 9 feet. At the time of spraying, the section was examined and 35 parent adult emergence holes were marked. When examined at a later date to determine if the chemical had affected new adult emergence, many new emergence holes were observed, which indicated the chemical had not destroyed the brood.

RESULTS OBTAINED FROM INJECTING SODIUM ARSENATE IN MOUNTAIN-PINE BEETLE INFESTED LODGEPOLE AT DIFFERENT TIMES AFTER ATTACK

In the plans projected for the 1932 season, it was decided to inject the same quantity of sodium arsenate in infested lodgepole pine at weekly intervals following attack to determine how long a period after attack it is possible to secure control of the mountain-pine beetle by tree medication, using the tin-collar method. Following this plan, trees were treated approximately 2, 4, 5, 7 and 9 weeks after they had been attacked, using a solution of 2 ounces of sodium arsenate dissolved

in two quarts of water. Extensive examinations were made of these trees in late October and early November of 1932, and at that time it was found that control had been apparently perfect in trees treated up to the fourth week after attack, but just as consistently lacking for the longer periods. However, it is assumed that a slow but quite general distribution of the poison through the connective tissue of the tree occurs during the late fall, winter, and spring months. The preceding data indicate that injection of sodium arsenate into trees within the period of one month from date of attack assures control of the infesting insects, but previous experience has shown that the final chapter on the effectiveness of control can not be written until thorough examinations have been made in the spring following the year the trees were treated.

Treatments with very small dosages of sodium arsenate gave no consistent indications of effectiveness when examined in late October and early November.

Three infested trees were treated with two quarts of a saturated solution of sodium fluosilicate in water, and in spite of being less than 1 per cent soluble extensive examination at the end of the season indicates good control. These trees were treated at 7, 8 and 12 days respectively from the date of attack. If the spring examination confirms the indication of good control, it is recommended that further experiments be conducted with this material, following the same plan as that outlined for the experiments with sodium arsenate in 1932.

INJECTION OF SODIUM ARSENATE BY MEANS OF THE BORED HOLE AND CAN METHOD

In using this method of injection four intersecting holes were bored tangential to the bole of the selected tree and parallel to the ground. A fifth short hole from the surface of the tree to one of the tangential borings was then made and fitted with the cork, which completed the connection between the rubber tube from the solution-filled can and the series of holes. Small pieces of grease-coated tin nailed over the ends of the tangential holes prevented leakage from them. Fading of the foliage of the tree was extremely rapid after the two ounces of sodium arsenate in two quarts of water had been absorbed by the tree. This method failed to produce the desired effect, as no mortality of parent adults or brood was noted in the two trees examined. The gradual distribution of poison which seems to occur during late fall, winter and spring months may result in control by the time of the June examination.

SELECTION SHOWN BY THE MOUNTAIN PINE BEETLE FOR VARIOUS SPECIES OF TREES AND REPELLENT TREATMENTS

The object of this experiment was to determine if attacks could be forced into heavily treated materials and into hosts other than the one from which the insects developed. A cage six feet square, shown in Figure 4 of Plate I, was constructed, which held a 5-1/2 foot log each of green lodgepole pine, white-bark pine and Engelmann spruce, four sections of lodgepole pine which had been treated with orthodichlorobenzene, pyridine, and two materials (Termex and impregnation formula) from the Hercules Powder Company. In addition, two heavily infested

sections of lodgepole pine from which the beetles were emerging were placed in the cage to supply the necessary insects to attack the enclosed logs. This experiment was begun on August 3 and 4 of 1932. It was originally planned to inspect the caged material daily and remove each section as soon as it was attacked, on the basis that these first attacks indicated the preference of the insects. Inspections were made on August 5 and 6, but other work prohibited another until August 21. At that time it was found all sections had been more or less attacked. In the succeeding tabulation the log sections have been listed according to the degree of attack, with the most heavily attacked one heading the list:

(1) Green lodgepole pine

(2) Green white-bark pine

(3) Orthene treated

(4) Impregnation formula treated

(5) Termex treated

(6) Pyridine treated

(7) Green Engelmann spruce

If we can assume that the degree of attack on the sections represents the preference of the beetles, we find lodgepole pine to be the preferred host. Judging by the almost identical number of attacks in two logs having the next heaviest infestation, there was little difference in choice shown by the beetles for green white-bark pine and the orthene-treated log. Similarly, there was little difference in the choice shown for the two logs next in order treated with the Hercules Powder Company products. The pyridine-treated log showed very few attacks, and only one was observed on the Engelmann spruce log.

From the data secured it is apparent that none of the materials tested showed sufficient repellent effect to prevent attack by the mountain pine beetle. In addition, lodgepole pine seems to be the preferred host, and Engelmann spruce even less desirable than the treated logs.

REPEATED ATTACKS BY NEW ADULTS AND OVERWINTERING PARENT ADULTS DURING THE SEASON OF 1932

The object of this experiment was to determine how many times adults of the mountain pine beetle emerge and duplicate attacks during a season. This information is of value in indicating the amount of a season's infestation which is due to this phase of the beetle's activity and its relation to the planning of control work. Logs were to be cut from trees of known date of attack and placed in a cage enclosing a green lodgepole pine of susceptible size. Examinations were to be made at intervals to determine when parent adults began to emerge and attack the green tree. Before they began to emerge from the second tree the infested logs were to be removed and placed in a second cage containing another green tree of susceptible size. This transfer was to be made so that identification of a third attack could be definite, which would have been impossible where there was a mingling of emerging adults from two sources.

Between June 23 and July 4 of 1932, two lodgepole pine near the Elkhorn Ranger Station were attacked by the mountain pine beetle. There were three possible sources of the insects attacking these trees: (1) new adults which overwintered as such and emerged earlier than the major portion of the brood which had overwintered as larvae; (2) new adults

which overwintered as larvae in trees favoring very rapid development and early emergence of the brood; and (3) parent adults which survived the winter. Extensive examinations of many trees in June of 1932 failed to indicate that either of the first two sources in the vicinity of Elkhorn could have caused the attacks. Although the insects making these attacks may have been new adults from distant sources, the writer believes they are more likely to have been parent adults that survived the winter and emerged to make another attack in June or early July of 1932. The probability that overwintering parent adults were the attacking insects was strengthened when it was found that 56 beetles taken from a section of one of the attacked trees were uniformly black in color. A considerable per cent of new adults vary from light to dark brown in color, whereas parent adults which have overwintered are, with few exceptions, black.

Logs from these two early attacked trees were caged with a green tree on July 5 of 1932. Examination of the cage on July 12 showed 2 attacks on the enclosed green tree. On July 15 the number had increased to 6, and on the 22nd to 8. On the 23rd, 4 attacks were noted above and 8 inside the cage. No change in the status of the caged or uncaged parts of the green tree occurred between July 23 and August 3. Examination on August 21 showed many more attacks on the enclosed green tree from parent adults emerging from the logs. The initially attacked logs were then moved to another cage enclosing a green tree, and an examination on October 27 showed 6 attacks on the green tree. It is not known at what time between August 21 and October 27 the six attacks occurred - neither can their origin be definitely established as they could have come from outside

the cage while the logs were being moved from the first to the second cage - but they could not have taken place before August 22. That gives the emergence period of overwintering parent adults from between June 23 and July 4 to at least August 22, a minimum of six weeks.

The first caged tree, which showed 18 attacks, was cut into logs and placed in a cage with an unattacked tree. None of the parent adults from this log attacked the third tree although one of the galleries showed emergence had occurred between August 22 and October 27. From this series of caging experiments, which probably involved overwintering parent adults, we learned that only two attacks are made by a small portion of the overwintering parent adults on lodgepole pine during the second summer.

On July 22 and 23, two cages were constructed enclosing a green tree and logs from trees which had been attacked during the period from July 18 to 22, 1932. In both cages parent adults from these logs made their first attacks on the green trees on August 2, and additional insects from the same source were attacking on August 22, when the logs were transferred to a second set of cages. Between August 2 and 22, parent adults had made 56 attacks on one of the enclosed green trees, and many more on the green tree in the second cage. The logs in both cages, from which the insects were still emerging, were then placed in one cage around a green tree, and it also showed many attacks when examined on November 1, 1932. These observations indicate that the first period of emergence of parent adults begins about two weeks after the trees are attacked and lasts at least three weeks, probably much longer.

The two green trees enclosed with the logs in the first two cages, and which were subsequently attacked by parent adults, were cut on August

22, and enclosed with another green tree. When examined on November 1, only three attacks had occurred on the green tree, indicating that very few parent adults attacked a third time in 1932. However, there is a possibility that these attacks were from insects which got into the cage at the time the logs were transferred.

Observations made of trees attacked on different dates showed a wide variation in the brood development. On November 1, the range was from eggs to new adults with, however, the number of new adults averaging much less than one per cent of the total. Pupae composed from one to five per cent of the total brood, but previous studies show they are unable to overwinter. Mature larvae comprised possibly 20 per cent of the total brood, other larval stages approximately 65 per cent, and eggs 10 to 15 per cent. The variation in development from eggs to mature larvae at the end of the winter season is probably the main reason for the long period of emergence of new adults of the mountain pine beetle. The new adults that overwinter are too few to be considered except as a potential source of some of the June attacks.

SUMMARY OF RESULTS FROM PARENT ADULT EMERGENCE STUDIES IN 1932

There are indications that some overwintering parent adults made as many as two new attacks in 1932, but those making the second attack are very few. Many new adults make a second attack in the same season, but very few, if any, make a third. The period from the first attack of a tree until the first parent adult emerges from it and attacks a second tree is about two weeks. Attacks on the second tree continue for an indefinite period known to be at least six weeks.

The data just discussed indicate that to prevent any attacks of a second tree by parent adults it is necessary that the trees be treated within two weeks after attack. However, if control were contemplated, trees treated within three weeks of the date of attack would involve all but a negligible portion of the parent adults. Unless additional advantages can be secured by such early treatment, it would not be economical as it requires the spotting and treating of the area at least twice in the same season.

Plate I illustrates two methods of injection treatment: the tin-collar saw-kerf method and the bored-hole method; a pyridine treated tree; and the cage containing the various treated and untreated logs used in the test of repellents.

Explanation of Plate I

Figure 1 - Pyridine treated lodgepole pine in central foreground.

Figure 2 - A mountain pine beetle attacked lodgepole pine treated by the tin-collar saw-kerf method.

Figure 3 - A mountain pine beetle attacked lodgepole pine treated by the bored hole and can method.

Figure 4 - The cage containing the various treated and untreated logs used in the test of repellents.

Plate I

Fig. 1

Fig. 2

Fig. 3

Fig. 4